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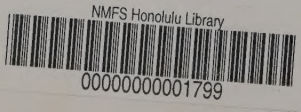
FISHERIES MANAGEMENT

1. CONSERVATION AND MANAGEMENT OF SHARKS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FISHERIES MANAGEMENT

1. CONSERVATION AND MANAGEMENT OF SHARKS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2000

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PREPARATION OF THIS DOCUMENT

In 1994, the Ninth Conference of CITES adopted a Resolution on the Biological and Trade Status of Sharks (Conf. 9.17), requesting that FAO and other international fisheries management organizations establish programmes to collect biological and trade data on shark species. This request lead to discussions at FAO's twenty-second session of its Committee on Fisheries (COFI) in 1997. Many delegations noted that conservation and effective management of shark populations merited further examination and thus FAO organized, with Japan and the United States, an expert consultation to develop guidelines for a plan of action to be submitted to the next session. The Committee also called upon regional fishery management bodies and other competent organizations to examine all aspects of shark conservation and management.

An International Plan of Action for Conservation and Management of Sharks (IPOA-SHARKS) was developed through the meeting of a Technical Working Group on the Conservation and Management of Sharks in Tokyo in April 1998 and a subsequent Consultation on Management of Fishing Capacity, Shark Fisheries and Incidental Catch of Seabirds in Longline Fisheries held in Rome in October of the same year. The IPOA-SHARKS was adopted by the 23rd session of COFI in 1999 who noted that the implementation of the plan should be pursued as high priority.

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It has to be stressed that these Guidelines have no formal legal status. They are intended to provide support for the implementation of the Code of Conduct for Responsible Fisheries. Furthermore, in order to present the management process in all its complexity and diversity, the wording and structure of these Guidelines do not follow strictly the language and structure of the Code. Therefore, any eventual differences in the terminology employed should not be understood as intending reinterpretation of the Code. Finally, it should be remembered that, since the Guidelines are intended to be flexible and capable of evolving as circumstances change, or as new information becomes available, they may be further revised and complemented by other guidelines, notes, etc., on specific issues.

Distribution:

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ABSTRACT

These Guidelines have been produced to support implementation of the International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks). The Guidelines are addressed to decision-makers and policy-makers associated with conserving shark and other chondrichthyan species and with managing the harvest of these resources, but they should be of interest to fishing industries and other parties.

The IPOA-Sharks is consistent with the FAO Code of Conduct for Responsible Fisheries, agreements from the 1995 United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, and any applicable rules of international law. It encompasses all shark and other chondrichthyan fisheries, both target and non-target fisheries, whether they be industrial, artisanal or traditional fisheries or fishing programmes designed to reduce risk of shark attack on humans.

The IPOA-Sharks is not a full strategic plan for the world, rather it prescribes a process whereby individual States, States participating in sub-regional arrangements through bilateral and multilateral agreements to manage shared transboundary shark stocks, and relevant regional fisheries management organizations (RFMO), identify national, subregional and regional issues and then develop national and regional 'Shark Plans' to address the issues.

The guiding principles of the IPOA-Sharks and the Guidelines are that States contributing to fishing mortality of a species or stock should participate in its conservation and management, and that, as a traditional and important source of food, employment and income, shark resources be used sustainably. The precautionary approach to conservation and management is embraced when the status of a resource is uncertain, such as when fishery data are insufficient or unreliable.

The Guidelines are intended to provide general advice and a framework for development and implementation of Shark Plans and Shark Assessment Reports prepared at national, subregional and regional levels. They are also intended to provide general advice and a framework for joint Shark Plans for shared transboundary species of shark. They cover the four elements ('species conservation', 'biodiversity maintenance', 'habitat protection' and 'management for sustainable use') of the IPOA-Sharks and the four dimensions ('ecological', 'economic', 'social' and 'governance') of the FAO 'Sustainable Development Reference System'.

The Guidelines outline various needs at each of the subnational, national, subregional, regional and global levels. The needs include development of appropriate legal, institutional and management frameworks and provision of human resources and capacity building requirements. Fishery monitoring and research requirements are described, with emphasis on the urgent need for specialist training, species catalogues, field guides, dissemination of information, common databases for transboundary species, and agreed uniform criteria for classifying the conservation status of species and their stocks. Outlined are needs for fisheries management controls on catch and effort, protection of critical habitats, and establishment of fishing exclusion zones to provide sanctuaries for protecting rare species or depleted stocks. There is a need to encourage the release of sharks live or, where retained, their full utilization. Also, there is a need to promote the development of shark bycatch reduction devices. The required information for the development of national, subregional and regional Shark Plans and Shark Assessment Reports are presented.

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BACKGROUND

1. From ancient times, fishing has been a major source of food for humanity and a provider of employment and economic benefits to those engaged in this activity. However, with increased knowledge and the dynamic development of fisheries, it was realized that living aquatic resources, although renewable, are not infinite and need to be properly managed, if their contribution to the nutritional, economic and social well-being of the growing world's population was to be sustained.

2. The adoption in 1982 of the United Nations Convention on the Law of the Sea provided a new framework for the better management of marine resources. The new legal regime of the oceans gave coastal States rights and responsibilities for the management and use of fishery resources within the areas of their national jurisdiction, which embrace some 90 percent of the world's marine fisheries.

3. In recent years, world fisheries have become a dynamically developing sector of the food industry, and many States have striven to take advantage of their new opportunities by investing in modern fishing fleets and processing factories in response to growing international demand for fish and fishery products. It became clear, however, that many fisheries resources could not sustain an often uncontrolled increase of exploitation.

4. Clear signs of over-exploitation of important fish stocks, modifications of ecosystems, significant economic losses, and international conflicts on management and fish trade threatened the long-term sustainability of fisheries and the contribution of fisheries to food supply. Therefore, the Nineteenth Session of the FAO Committee on Fisheries (COFI), held in March 1991, recommended that new approaches to fisheries management embracing conservation and environmental, as well as social and economic, considerations were urgently needed. FAO was asked to develop the concept of responsible fisheries and elaborate a Code of Conduct to foster its application.

5. Subsequently, the Government of Mexico, in collaboration with FAO, organized an International Conference on Responsible Fishing in Cancún in May 1992. The Declaration of Cancún endorsed at that Conference was brought to the attention of the UNCED Summit in Rio de Janeiro, Brazil, in June 1992, which supported the preparation of a Code of Conduct for Responsible Fisheries. The FAO Technical Consultation on High Seas Fishing, held in September 1992, further recommended the elaboration of a Code to address the issues regarding high seas fisheries.

6. The One Hundred and Second Session of the FAO Council, held in November 1992, discussed the elaboration of the Code, recommending that priority be given to high seas issues and requested that proposals for the Code be presented to the 1993 session of the Committee on Fisheries.

7. The Twentieth Session of COFI, held in March 1993, examined in general the proposed framework and content for such a Code, including the elaboration of guidelines, and endorsed a time frame for the further elaboration of the Code. It also requested FAO to prepare, on a "fast track" basis, as part of the Code, proposals to prevent reflagging of fishing vessels which affect conservation and management measures on the high seas. This resulted in the FAO Conference, at its Twenty-seventh Session in November 1993, adopting the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, which, according to FAO Conference Resolution 15/93, forms an integral part of the Code.

8. The Code was formulated so as to be interpreted and applied in conformity with the relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea, 1982, as well as with the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 1995, and in the light of, *inter alia*, the 1992 Declaration of

Cancún and the 1992 Rio Declaration on Environment and Development, in particular Chapter 17 of Agenda 21.

9. The development of the Code was carried out by FAO in consultation and collaboration with relevant United Nations Agencies and other international organizations, including non-governmental organizations.

10. The Code of Conduct consists of five introductory articles: Nature and Scope; Objectives; Relationship with Other International Instruments; Implementation, Monitoring and Updating and Special Requirements of Developing Countries. These introductory articles are followed by an article on General Principles, which precedes the six thematic articles on Fisheries Management, Fishing Operations, Aquaculture Development, Integration of Fisheries into Coastal Area Management, Post-Harvest Practices and Trade, and Fisheries Research. As already mentioned, the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas forms an integral part of the Code.

11. The Code is voluntary. However, certain parts of it are based on relevant rules of international law, as reflected in the United Nations Convention on the Law of the Sea of 10 December 1982. The Code also contains provisions that may be or have already been given binding effect by means of other obligatory legal instruments amongst the Parties, such as the Agreement to Promote Compliance with Conservation and Management Measures by Fishing Vessels on the High Seas, 1993.

12. The Twenty-eighth Session of the Conference in Resolution 4/95 adopted the Code of Conduct for Responsible Fisheries on 31 October 1995. The same Resolution requested FAO *inter alia* to elaborate appropriate technical guidelines in support of the implementation of the Code in collaboration with members and interested relevant organizations.

ACRONYMS

BRD	By-catch reduction device
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COFI	FAO Committee on Fisheries
CPUE	Catch per unit of effort
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization of the United Nations
IATTC	The Inter-American Tropical Tuna Commission
ICCAT	The International Commission for the Conservation of Atlantic Tunas
IOTC	Indian Ocean Tuna Commission
IPOA-Sharks	International Plans of Action for the Conservation and Management of Sharks
OLDEPESCA	Latin American Organization for Fisheries Development
RFMO	Regional Fisheries Management Organization
SDRS	Sustainable Development Reference System
SPC	Secretariat of the Pacific Community

1. INTERNATIONAL PLANS OF ACTION - SHARKS

1.1 Origin of IPOA-Sharks

There is widespread concern over the increase of shark fishing and the consequences which this has for the populations of some shark species in several areas of the world's oceans. The prevailing view is that it is necessary to control directed shark fisheries and fisheries in which sharks constitute a significant bycatch.

Currently few countries manage their shark fisheries and there are no international management mechanisms actively addressing the capture of sharks; however, since initiation of the process to develop the International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks), some regional bodies have begun encouraging member countries to collect information about sharks.

Noting the increased concern about expanding fisheries for sharks and the potential negative impacts on shark populations, CITES Resolution Conf. 9.17 requested the Food and Agriculture Organization of the United Nations (FAO) to gather necessary information on sharks to develop and propose guidelines leading to a plan of action for the conservation and management of sharks. CITES Decision 10.126 confirmed FAO's action. A proposal was subsequently developed at the 22nd Session of the FAO Committee on Fisheries (COFI) during March 1997 that FAO organize an expert consultation, using extra-budgetary funds, to develop Guidelines leading to a Plan of Action. The Governments of Japan and the United States agreed to provide the extra-budgetary funds required and to collaborate with FAO in organizing such a consultation.

The IPOA-Sharks has subsequently been developed through the meeting of the Technical Working Group on the Conservation and Management of Sharks held in Tokyo during 23–27 April 1998, and the Consultation on Management of Fishing Capacity, Shark Fisheries and Incidental Catch of Seabirds in Longline Fisheries held in Rome during 26–30 October 1998 and its preparatory meeting held in Rome during 22–24 July 1998.

The IPOA-Sharks consists of 31 paragraphs and 2 appendices endorsed by the member nations of COFI at the 26–30 October 1998 meeting. The IPOA-Sharks was subsequently endorsed 23rd Session of COFI in Rome during 15–19 February 1999.

1.2 The purpose of the IPOA-Sharks

The overall objective of the IPOA-Sharks is to ensure the conservation and management of sharks and their long-term sustainable use. There are three guiding principles associated with meeting this objective.

Participation. States that contribute to fishing mortality on a species or stock should participate in its management.

Sustaining stocks. Management and conservation strategies should aim to keep total fishing mortality for each stock within sustainable levels by applying the precautionary approach.

Nutritional and socio-economic considerations. Management and conservation objectives and strategies should recognize that in some low-income food-deficit regions and/or countries, shark catches are a traditional and important source of food, employment and/or income. Such catches should be managed on a sustainable basis to provide a continued source of food, employment and income to local communities.

The IPOA-Sharks is voluntary. It has been elaborated within the framework of the Code of Conduct for Responsible Fisheries as envisaged by Article 2 (d). The provisions of Article 3 of the Code of Conduct apply to the interpretation and application of the IPOA-Sharks and its relationship with other international instruments. All concerned States are encouraged to implement it.

The IPOA-Sharks and its appendices are appended to these Guidelines. The main text of the 31 ratified paragraphs of the IPOA-Sharks is presented as Appendix I, and its appendices are presented as Appendix II (Suggested Contents of a Shark Plan) and Appendix III (Suggested Contents of a Shark Assessment Report). Appendix IV presents a Classification of Shark Fisheries.

The IPOA-Sharks is not a full strategic plan for the world, rather it prescribes a process whereby individual States, relevant sub-regional arrangements through bilateral and multilateral agreements, and relevant regional fisheries management organizations (RFMO), identify national, sub-regional and regional issues and then appropriately develop national, sub-regional and regional 'Shark Plans' to address the issues. Each State and RFMO (an where required each sub-regional entity) should regularly carry out a regular assessment of the status of its shark stocks subjected to fishing so as to determine whether or not there is a need to develop a Shark Plan. Once at least every four years, States and RFMOs that implement a Shark Plan should assess its implementation for the purpose of identifying cost-effective strategies for increasing its effectiveness. Each State and each RFMO should strive to have its first Shark Plan prepared for the COFI Session scheduled for February 2001.

The present document 'Technical Guidelines for Implementation of the International Plan of Action for Conservation and Management of Sharks' provide technical guidance on the development and implementation of Shark Plans and for preparation of Shark Assessment Reports. In addition to preparing these guidelines, FAO, as part of its Regular Programme of activities, support States in the implementation of the IPOA-Sharks, including the preparation of Shark Plans and provision of in-country technical assistance. FAO will report biennially through COFI on progress of the implementation of the IPOA-Sharks.

1.3 Elements of IPOA-Sharks

For the purposes of this document, the term 'shark' is taken to include all species of sharks, skates, rays and chimaeras (Class Chondrichthyes), and the term 'shark catch' is taken to include directed (targeted), non-directed (non-targeted), bycatch (discards), commercial, recreational and other forms of taking sharks.

Four elements of the IPOA-Sharks include (a) the particular conservation needs of some shark and other chondrichthyan species, (b) the need for maintenance of biodiversity through viability of shark populations, (c) the need for habitat protection, and (d) the management requirements of shark fishery resources for sustainable use. These elements apply variously for different species and relate to the principles of 'ecologically sustainable development' and 'inter-generation equity' in that they should provide ongoing benefits to successive generations of humans.

Species conservation. Some species of shark need 'special protection' (or 'special management'). This is because some species of shark have particularly low productivity, naturally small populations (rare), a spatially small distribution range, or a distribution range within regions of high anthropogenic impact where they might be threatened or have their populations severely depleted. Such species may need special protection through management action such as prohibition of their capture, prohibition of specific fishing gears, or closed areas to their capture or use of specific fishing gears.

Biodiversity maintenance. Biodiversity is the variety of living organisms in all their forms and defined in terms of genetic diversity, species diversity and ecosystem diversity and the interrelations

between genes, species and ecosystems. The number of species and within-species genetic variability of shark and other chondrichthyan species is naturally low compared with those of many other taxonomic groups. The loss of species, the loss of individual populations within a species, or loss of genetic variation within a species or population, and consequential loss of ecological processes reduce biodiversity and benefits to human kind. Loss of biodiversity can be caused by increased mortality, loss or degradation of habitat, change of environment, and changes in competition with other species, resulting from the introduction of exotic or genetically altered species or from other ecological changes.

Habitat protection. Anthropogenic activity such as fishing, aquaculture, ecotourism, dredging, mining, catchment area clearing, dumping, nutrient enrichment, pollution, or introduction of exotic organisms can lead to broad-scale degradation of a species habitat range or loss of critical habitat such as nursery, pupping and mating areas or migration lanes of a species. Special habitat protection or habitat restoration programmes might be required where a species abundance or range has been reduced as a result of habitat loss.

Management for sustainable use. Sustainable use requires an understanding of the biophysical and ecological systems and requires maintaining stocks at, or restoring to, levels above those capable of producing maximum sustainable yields. The concept of sustainable catch has to be viewed within the constraints that ecosystems are in dynamic equilibrium and shift between different states depending on natural oscillations in the environment such as El Niño, on anthropogenic stress such as fishing and other activities impacting ecosystems, and, possibly, on climate change. Managing shark resources for sustainable use involves controlling fishing mortality through limiting fishing effort and/or catch and through biological controls such as legal minimum lengths, prescribed mesh-sizes or hook sizes of the fishing gear, closed seasons and closed areas.

Precautionary approach and IPOA-Sharks

The precautionary approach requires fisheries managers to be cautious when the state of a resource is uncertain, such as when fishery data are insufficient or unreliable. When faced with such uncertainty, managers are required to ensure that exploitation is conducted at a minimal level. The precautionary approach has been embodied in two important international initiatives: the 1995 United Nations Agreement on Straddling and Highly Migratory Fish Stocks and the 1995 FAO Code of Conduct for Responsible Fisheries.

The low productivity of shark stocks in general, the particularly low productivity of some species of shark, and naturally small population size or rarity of some species of shark implies that the precautionary approach is most applicable to this group of fishes. Their stocks can often be rapidly depleted to very levels and be slow to recover from the effects of overfishing. Controls should be implemented early during the developmental phases of fisheries taking sharks and other chondrichthyan species.

2. INTRODUCTION

2.1 Purpose and scope of guidelines

These guidelines have been produced to support implementation of the International Plan of Action for the Conservation and Management of Sharks. The guidelines are aimed at government, fisheries agencies at sub-national, national, regional and international level, and non-government organizations. They are designed to raise awareness of the conservation and management needs of sharks and other chondrichthyans and should be interest to fishing companies and other parties involved in the harvest of these resources.

The guidelines provide general advice and a framework for development and implementation of national Shark Plans for conservation and management of sharks consistent with the IPOA-Sharks. The guidelines are also intended to provide information to assist with the preparation of shark assessment reports. The guidelines also provide nations and RFMOs with general advice on requirements and a framework for development and implementation of Shark Plans for conservation and management of transboundary species of shark.

These guidelines are not intended to be a manual on methods of management, monitoring and research for shark fisheries. The guidelines have no formal legal status.

2.2 Definitions

Batoids: Skates and rays, which include guitar fishes, sawfishes and electric rays, are dorsoventrally flattened and generally suited for life on the bottom. They have enlarged wing-like pectoral fins and 5–6 ventrally located gill openings. There are about 600 species worldwide.

Chimaera: Chondrichthyans are taxonomically separate from Elasmobranchs (sharks, skates and rays). There are about 35 species world-wide and all are marine. They have large heads, smooth skin without scales and often have whip-like tails. There is a long sharp spine on the leading edge of the first dorsal fin.

Gill-slits: Narrow gill openings behind the head.

Pectoral fins: Paired fins just behind or below the gill-slits; united to form disc in most rays.

Pelvic fin: Paired fins (rarely joined) positioned on the underside between the head and vent.

Sharks: True sharks are mainly fusiform in shape although a few species are ray shaped with 5–7 gill openings. There are about 400 species world-wide.

'*Special protection' or 'special management*': A term adopted for species requiring special protection or management because of its poor conservation status or rarity. This term is adopted to replace terms such as 'endangered', 'threatened', 'vulnerable' or 'depleted species' or 'in danger of extinction'. Some countries have adopted definitions for some of these terms, which have legal standing in their jurisdictions, and some international organizations have published classification criteria for the conservation status of species, but, as yet, there is no single set of criteria accepted by all nations.

State: Country, nation, fishing entity or any entity, or organization, to which countries have transferred their right to set policies and manage fisheries.

Wild fisheries: Fisheries based on the harvest of natural populations and recruitment.

2.3 Characterization of sharks and other chondrichthyans and their fisheries

Sharks, skates, rays and chimaeras are often characterized as long-lived, slow-growing and producing few offspring. These characteristics are associated with low productivity, close stock-recruitment relationships and slow stock recovery in the event of overfishing.

The number of species is small compared with the number of species of teleost and various phyla of invertebrates. About 1000 chondrichthyan species have been described from a variety of habitats from near shore to the ocean abyss. They are most numerous at depths less than 2000 m in tropical and warm temperate marine habitats, but a few occur in freshwater and hypersaline habitats.

The use of shark and other chondrichthyan products pre-dates recorded history, and every part of these animals has been used for some purpose. Shark meat is important food consumed fresh, dried, salted or smoked in many communities. The demand for fins of sharks is growing such that they are among the world's most expensive fishery products, and recently demand has been increasing for shark cartilage and other products for medicinal purposes. In some fisheries only the meat is retained, while the rest of the animal is discarded. In other fisheries, only the fins, or liver or skin are retained; few fisheries utilize all parts of the animals. Given the growing demand for shark products while many stocks are in decline, there is an urgent need to rationalize current patterns of usage.

Fisheries taking sharks and other chondrichthyans are common throughout the world and, although the overall number of species harvested is relatively small, they are taken with a variety of types of fishing gear and vessels. Sharks are taken mainly by gillnet, hook or trawl in industrial and artisanal fisheries. Small amounts are taken in traditional and recreational fisheries (including game fishers and divers) and in beach gillnet and drumline fishing bather protection programmes. There are several fisheries directed at one or a small number of species of shark, but most sharks are taken in multispecies fisheries where the fishers tend to target more highly valued teleosts. In some fisheries part or the entire shark catch is discarded.

Shark fisheries cannot be simply classified to avoid overlap of the species caught, but for the purpose of these Guidelines they are classified as 'coastal hook and gillnet fisheries', 'demersal trawl bycatch fisheries', 'deepwater bycatch fisheries', 'pelagic bycatch fisheries (primarily bycatch in tuna longline and purse seine fisheries)' and 'freshwater shark fisheries' (see Appendix 2).

2.4 Issues

The lack of public awareness of the conservation needs, which stems from the low productivity of sharks, and the historically low value of shark products are the main reasons why few countries currently manage their shark fisheries. Furthermore, until very recently, none of the RFMOs actively addressed the capture of sharks. However, there are indications that an international consensus is beginning to emerge on the need for improved control of fishing for shark and other chondrichthyan species. The prevailing view is that it is necessary to control shark directed fisheries and implement bycatch reduction devices (BRD) for fisheries in which sharks constitute a significant discarded bycatch.

Managers need to approach the management of fisheries for sharks somewhat differently from the approach they normally use in the management of marine capture fisheries. This is because sharks often have a close stock-recruitment relationship, long recovery periods in response to overfishing and complex spatial structures (size/sex segregation). In addition, they are generally difficult to identify down to the species level.

A major difficulty in assessing shark fishery stocks is that the number of species targeted is small and therefore they have not been intensively studied as a group. Furthermore, most of the shark catch is taken by fishers targeting teleost species which results in most of the catch reported as unidentified shark or mixed fish or not reported at all. This lack of species identification for catches and lack of information on fishing effort means basic data for fishery stock assessment are currently available for only a few species.

Furthermore the state of knowledge of sharks and the practices employed in shark fisheries cause problems in the conservation and management of sharks. Some areas require urgent attention.

- Taxonomic problems need to be resolved, particularly with batoids, before effective monitoring, research and management can be achieved.

- Heading, gutting and finning sharks at sea creates difficulties in identifying species after landing.

- Available catch and effort data for sharks and other chondrichthyans are inadequate in most fisheries.

- Biological parameters of growth and reproduction have been determined for some species, but other fundamental data, such as fishing effort, catch and species, sex, length and age composition of the catch required for stock assessment, are not available for most species.

- Widespread multi-species fisheries take a variety of species all with different potential for sustainable use. Thus, when sharks constitute part of the catch it may be difficult to achieve a management goal for sharks only.

- There is a general lack of knowledge about critical habitat areas for sharks and other chondrichthyans.

- There is little facility to coordinate collection of information on transboundary species due to lack of responsibility for these stocks, particularly in international waters.

- There is a lack of funds for monitoring, research and management of sharks and other chondrichthyans.

Most species of shark are captured in multi-species fisheries directed at more productive and more highly valued teleost species. Harvest strategies designed to maximize economic and social benefits from these multi-species fisheries will inevitably deplete the less productive shark and other chondrichthyan species unless methods for reducing the catch of the less productive species can be developed and implemented. As fishing effort increases characteristic and predictable changes occur in the fish assemblages which have major implications for sustainability and management. In general as effort increases larger individuals and species disappear from the assemblage to be replaced by smaller counterparts. This results in a gradual drift towards shorter-lived, faster-growing species. This is accompanied by an initial increase and later a decrease in the number of species in the exploitable population although the number of fish actually appearing in the catch can increase until a maximum level is passed.

3. LEGAL, INSTITUTIONAL AND MANAGEMENT FRAMEWORK REQUIREMENTS

Implementation of the IPOA-Sharks presupposes a minimum set of institutional arrangements and recurrent activities at local, sub-national, national, sub-regional, regional and global levels. States, RFMOs and other entities engaged in fisheries management should, through appropriate policy, legal and institutional frameworks, adopt measures for the long-term conservation and sustainable use of shark fishery resources. Conservation and management measures should be based on the best scientific evidence available and be designed to ensure the long-term sustainability of shark fishery resources. The resources should be maintained at levels that promote the objective of their optimum utilization and maintain their availability for present and future generations; short-term considerations should not compromise these objectives.

To be effective, management of shark fisheries has to be concerned with the whole stock units over their entire areas of distribution. The best scientific evidence available should be used to determine the area of distribution of the resource and the area through which fish in the stock migrates during its life cycle. Where a stock falls entirely within the Exclusive Economic Zone of a single nation then that resource can be managed under the single jurisdiction of that nation. However, where a stock is distributed in the EEZs of more than one nation or where it is distributed on the high seas,

jurisdictional arrangements are more complex. Such shared or transboundary straddling stocks can only be managed through bilateral and multilateral arrangements or RFMOs.

All countries are free to fish the high seas and regulation is beyond the control of any individual country. To enable cooperative management for sustainable use of straddling and highly migratory fish stocks, a United Nations treaty was established. This treaty is the Agreement for the Implementation of the United Nations Convention on the law of the Sea of 10 December 1982 Relating to the Convention and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. It is also referred to as the UN Fish Stocks Agreement. Ratification of the Agreement by nations provides rights, obligations and fisheries management principles for the long-term conservation and sustainable use of straddling and highly migratory fish stocks. The Agreement implements a framework for greater cooperation between fishing nations, including through RFMOs. It will provide rights to member nations of RFMOs to board and inspect fishing vessels on the high seas to check compliance with regionally agreed conservation and management measures. Nations signing the Agreement signal their acceptance of the principles of the Agreement.

'Flag State responsibility' is a principle of international law and is reinforced by the UN Fish Stocks Agreement. The national law that applies to a vessel on the high seas is the law of the country whose flag the vessel is entitled to carry. This is termed the 'flag State'. If there is any infringement of rules, the flag State of the vessel concerned is responsible for undertaking investigation and appropriate enforcement action.

3.1 National and sub-national legal and institutional frameworks

States endorsing the IPOA-Sharks should develop, as appropriate, institutional, policy and legal frameworks to achieve the conservation of sharks and other chondrichthyans and sustainable use of shark resources and to govern access to them, taking account of the comparatively low productivity and finite nature of shark resources. In conformity with these frameworks and their national and sub-national laws, States should implement appropriate effective shark fishery monitoring, research, management, surveillance and law enforcement measures including, where appropriate, observer programmes, inspection schemes and vessel monitoring systems. Such measures should be promoted and, where appropriate, implemented in accordance with procedures agreed through bilateral or multilateral arrangements or RFMOs.

States should provide facilities and promote monitoring and research in support of shark fishery assessment and management and species conservation, including research on the resources and the effects of climatic, environmental and socioeconomic factors. The results of such research should be disseminated to all interested parties. Studies should be promoted to provide an understanding of the costs, benefits and effects of alternative management options designed to rationalize shark catches and levels of fishing effort.

Effective coordination of implementation of the IPOA-Sharks at the national level through development of Shark Plans and ongoing Shark Assessments requires a structure, a definition of roles, an agreed process and mobilization of resources. The process should ensure that representatives of the various fisheries sectors, fishing communities, non government organizations and other interested parties are consulted in the decision-making process and involved in other activities related to shark conservation and shark fishery management planning and development. The process should promote the creation of public awareness of the need for the management of shark resources and the participation in the management process by those affected.

3.2 Regional and sub-regional institutional frameworks

States endorsing the IPOA-Sharks accept that international cooperation is essential for its successful implementation. Responsibilities under existing bilateral and multilateral sub-regional arrangements and RFMOs should be extended to include, or give higher priority to, shark fisheries. Where necessary, to manage fisheries harvesting shared or transboundary stocks, new regional and sub-regional agreements should be established.

Conservation and management measures should be established for transboundary shark stocks, straddling shark stocks, highly migratory shark stocks and high seas shark stocks throughout their range, in accordance with the respective competencies of relevant States or, where appropriate, through bilateral and multilateral arrangements and RFMOs; the measures should be compatible. There needs to be agreement on the means by which the activities of such organizations and arrangements will be financed, bearing in mind, *inter alia*, the relative benefits derived from the shark fishery and the differing capacities of countries to provide financial and other contributions. Where appropriate, and where possible, such organizations and arrangements should aim to recover the costs of monitoring, research, management, surveillance and enforcement.

States that are members of RFMOs participating in bilateral and multilateral sub-regional arrangements should implement internationally agreed measures adopted in the framework of such organizations or arrangements and consistent with international laws. It is particularly important to deter the activities of vessels flying the flag of non-members or non-participants which engage in activities that undermine the effectiveness of conservation and management measures established by such organizations or arrangements. Modification of bilateral and multilateral arrangements and of the statutes of RFMOs to accommodate work on conservation and management of sharks will be pursued by FAO without any additional expense, and carried out mostly by the concerned organizations at the behest of their member countries.

The Inter-American Tropical Tuna Commission (IATTC), the International Council for the Exploration of the Sea (ICES), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Latin American Organization for Fishery Development (OLDEPESCA), the Indian Ocean Tuna Commission (IOTC) and South Pacific Commission (SPC) have recently initiated efforts encouraging member countries to collect information about sharks.

3.3 Global institutional frameworks

A mechanism will be established by FAO to coordinate the international collaboration required for developing and implementing the IPOA-Sharks. Through this mechanism national governments and RFMOs will be encouraged to develop and implement Shark Plans and undertake Shark Assessments under legislation applicable in the regions of their jurisdictions and, where appropriate, under existing bilateral, multilateral and international protocols, conventions and agreements.

4. HUMAN RESOURCES AND CAPACITY BUILDING REQUIREMENTS

States endorsing the IPOA-Sharks should be able to assess the state of the stocks under their jurisdictions, including the impacts of ecosystem changes resulting from the effects fishing, pollution and habitat change. They should also have the research capacity to assess the effects of climate change or environmental change on shark stocks. Such research should meet acknowledged scientific standards. Data generated by research and monitoring should be promptly analysed and the results published in a readily understood style and should be made available for peer review to ensure procedures and standards adopted are defensible.

There is a need to provide appropriate staffing, training, buildings and other facilities to undertake monitoring, research and management of shark resources. In most instances the amount of human and financial resources accessible to shark researchers and managers must increase for conservation and management to improve.

Training is a crucial component in the preparation and successful implementation of data collection programmes and must be given high priority. Adequate training and supervision of staff involved in fishery monitoring are essential if the data collected are to be valid. Staff are frequently expected to work in remote areas or as sole observers aboard ships, often with no contact with their supervisors or colleagues for extended periods. Regular visits, incorporating quality control, should be made by supervisory staff to data collection sites and regular in-service training sessions need to be held. Training courses and workshops should target a representative number of national staff involved in various phases of a fishery data collection programme and should be an ongoing activity. Participants should include fishers, data collectors, supervisors, researchers, computer operators, and decision makers.

It is desirable to establish stakeholder partnerships and co-management structures, involving the fisheries sectors together with public policy-makers and fisheries scientists, external funding bodies, and stakeholders representing community interests. Training for stakeholders participating in these processes is also desirable.

Limited technical and capital resources and gaps in scientific training in many developing countries mean that development assistance including science and technology contributions from other countries is a required for widespread implementation of the IPOA-Sharks. International cooperation is one way of building up management, reporting and monitoring capacity in countries where fisheries science and ecosystem management needs to be developed. This should be a partnership that involves local and external experts to bring together available knowledge, to organize it, and to build capacity.

States endorsing the IPOA-Sharks should, where appropriate, provide resources to support development regional Shark Plans and participate in existing or new bilateral and multilateral aggreements and RFMOs for the conservation and management of shark resources.

5. FISHERY MANAGEMENT DATA AND RESEARCH

5.1 National requirements

States should recognise that conservation and management of sharks requires the availability of sound scientific basis to assist fisheries managers and other stakeholders in making decisions. Therefore, they need to ensure appropriate research is undertaken into all aspects of fisheries including biology, ecology, technology, environmental science and economics.

States should promote the use of research results as a basis for setting management objectives, biological reference points, sustainability indicators, acceptable risk levels, time frames and performance criteria, as well as ensuring adequate linkages between applied research and fisheries management.

5.2 Regional and sub-regional requirements

States should support the establishment of mechanisms, inter alia, to facilitate shark research and fishery monitoring at regional and sub-regional levels and should encourage the sharing of data and the results of such research between regions and sub-regions. Collaborative monitoring and research programmes to enable stock assessment of shared transboundary shark species should be

established through RFMOs and bilateral and multilateral sub-regional arrangements. States should conform to agreed monitoring and research procedures and data resolution to ensure uniform approaches at the regional and sub-regional levels for shared transboundary shark stocks.

5.3 Shark fishery descriptions

The Code of Conduct for Responsible Fisheries requires that policy decisions on regional, sub-regional, national or local fisheries be formulated and made in the full knowledge of the nature of the fisheries under consideration, including the different fishing groups or fleets and their composition, as well as the fishing grounds they use or propose to use.

Fisheries policy decisions should be made with the following information:

- interest groups, their features and their interests in the fishery,
- the economic factors related to the fishery, particularly the economic and social dependence of the different interest groups on the fishery,
- details of costs and benefits to the region, nation or local area from the fishery,
- the role of the fishery in providing employment for the different groups or communities,
- the alternative sources of employment and income for the different interest groups or communities,
- the current status of access to or ownership of the resources,
- the institutions currently involved in decision-making within the fishery, and
- an outline of the history of the fishery and the historical roles of the different interest groups within the fishery.

The fishery on any given stock may be simple, consisting of a single, relatively homogenous fleet. Alternatively, it may be complex, consisting of several fleet types ranging from, for example, sophisticated factory fleets to fleets of artisanal vessels, with each fleet using distinctive gear with distinct selectivity patterns or fishing different fishing grounds.

Data and information should be collected and analysed on each fleet such as:

- the number of vessels or units,
- their gear characteristics and the selectivity of the gear,
- any season patterns in the fishing,
- the locality of fishing in relation to the distribution of the stock and other fleets,
- any navigational and technological aids which assist in fishing, and
- other related factors.

5.4 Species identification

Field guides should be prepared to enable species identification from whole animals, carcasses and, possibly, fins, skins, vertebrae and heads.

Any fisheries monitoring, research or management programme requires that the species composition of the catch can de determined. Apart from general taxonomic uncertainties associated with a large number of species of sharks and other chondrichthyans, common practices of heading, gutting, finning, skinning and filleting or excising livers at sea exacerbates the problem for identifying the species of a shark in the catch. Although 'rapid genetics-based identification techniques' based on electrophoretic and on nuclear and mitochondrial DNA techniques can be adopted for determining species, these techniques require expensive and time-consuming procedures which are usually not suitable for routine monitoring or surveillance. Hence, effective onshore monitoring and surveillance of the catch requires the sharks to be landed in a form that enables species identification.

Fishers should not be forced to land sharks whole, because sharks should be gutted and gilled as soon as practicable after capture to avoid degrading the quality of the meat and other products. One option that usually enables species, sex and partial length of a shark to be determined is to have regulations allowing sharks to be headed and gutted at sea but requiring the sharks to be landed ashore as carcasses with fins, skin, claspers and, where applicable, dorsal spines attached. Leaving the head attached, with removal of the gills, is an option where species identification from the carcass form is uncertain.

If there is a requirement for species identification for marketing or trade purposes, there will be a need to develop field guides based on fins and other body parts. There will also be legislative requirements to ensure that shark products (carcasses, meat, fins, skins, heads, vertebral columns, livers, liver oil and jaws) are clearly labelled with species name.

5.5 Stock identification and stock structure

Stock identification and structure are integral components of fisheries stock assessment and are required for effective fisheries management and for 'special management' of species considered endangered or severely depleted. Stock identification and stock structure help determine the appropriate scale for development of monitoring and fishery harvest strategies or 'special management'.

Genetic, phenotypic and tagging techniques are available for stock identification. Genetic variation between stocks can provide a direct basis for determining stock structure, as molecular genetic techniques can be a robust tool for identifying reproductive isolation between stocks. Higher levels of genetic variation and larger numbers of alleles in some mitochondrial and nuclear (microsatellite) DNA markers suggest that DNA-based techniques usually provide greater resolution than allozyme-based techniques. Phenotypic variation between stocks can provide an indirect basis for stock structure, and although it does not provide evidence of genetic isolation between stocks, phenotypic variation can indicate whether animals in different environmental regimes have undergone prolonged isolation. Phenotypic variation in meristic and morphological characters can be used for inferring stock structure. Also, in some cases, vertebral composition, in terms of elements such as calcium, strontium, carbon and oxygen, might provide a basis for distinguishing between separate nursery areas or between regionally separated stocks. Tag release-recapture and tag tracking data can also be used for stock identification, as well as for determining patterns of migration and rates of movement between separate regions of a fishery.

Overall stock size is of primary importance for any species or population, but the stock status can be more accurately assessed if account is taken of stock structuring by sex, size, age and stage of maturity of the sharks. This sort of structuring is common among shark species, and the recapture of tagged sharks at positions long distances from the positions of release indicates that many species are highly migratory. There is also evidence of mixing between genetically distinct populations. Such complex stock structuring, together with the practice of fishers targeting more than one species, complicate interpretation of CPUE and, without spatial disaggregation of the data, can cause CPUE to be an unreliable index of relative abundance. These complexities need to be accounted for in stock assessment models.

A single population with high rates of mixing between separate regions of a fishery (whether the population be homogenously distributed or highly structured) needs to be assessed and managed as a single stock. However, a single homogenously distributed population, with low rates of mixing between separate regions of a fishery, might be more appropriately assessed and managed as regionally separate sub-stocks. Spatially-separate populations, where there is minimal mixing, should normally be assessed and managed as separate sub-stocks, but the fleet dynamics of the fishery might necessitate the fishery to be assessed and managed as a single unit. On the other hand, in shark

fisheries where there are marked spatial structuring and mixing between separate breeding populations, multi-stock models are required. Furthermore, where the rates of mixing between different regions of a fishery are high, spatially-structured models incorporating movement rates between separate regions of the fishery are required for stock assessment.

5.6 Fishery monitoring

5.6.1 Catch: landings and discards

Total catch in numbers or weight needs to be recorded or estimated because it represents removal of biomass and individuals from the ecosystem and is the fundamental impact fishing has on fish populations. Catch data are required for most stock assessment techniques and as a variable for monitoring fluctuations in the stock. Where both weight and numbers are recorded, mean weight of shark in the catch can be determined.

Catches should be broken down into categories with as much detail as possible. The priority should be by species, location and date. Further breakdown by sex and length of shark (or broad size category or maturity) enable application of sex-based and length-based stock assessment models.

Discarding of sharks dead or in poor condition has important biological implications and should always be recorded or estimated. Total catch consists of total landings and discards. Shark bycatches, whether retained or discarded, should also be recorded.

Transhipping of sharks at sea must be incorporated into any catch monitoring scheme; otherwise a considerable proportion of the catch may be unaccounted for. This might need to be monitored with on-board observers or contacts through the Flag State of the receiving vessel.

Sharks are often headed, gutted and finned before landed ashore and facility should exist for conversion to live weight equivalent units (also called nominal catch or whole or round weight) using appropriate conversion factors. Hence, wherever forms have provision for recording weight of catch, there must also be provision for reporting the form of the sharks (i.e. whole, headed and gutted carcass with fins on, headed and gutted carcass with fins off, fins only or liver only). Without this provision catch weights will be ambiguous.

Total landings can be obtained from logbooks, sales slips or interviews with fishers or intermediaries. Discard estimates can sometimes also be obtained from fishers. Data from on-board observers during fishing trips can be valuable where detailed trip information on discards and fishing locations are not available.

5.6.2 Fishing effort

Fishing effort in stock assessments can be related to fishing mortality. To relate fishing effort to fishing mortality for use in stock assessment models, it is necessary to relate it very closely to specific gear use. This varies with gear. Units of fishing effort for gillnets are kilometre-lifts or kilometre-hours which requires recording total length of gillnets and soak time. Similarly units for hooks are hook-lifts and hook-hours which requires recording total number of hooks set and soak time. Soak time becomes invalid after baits are lost from the hooks. Soak times for gillnets and longlines with baited hooks have three phases: setting period, hauling period, and period between. Units for trawls are distance trawled, which can be determined from vessel positions at start and end of each haul or from trawl time and trawl speed. Species or group of species targeted should be recorded because this can greatly affect catch per unit effort (CPUE).

Height and mesh-size of gillnets, hook-size, average distance between hooks and baits, and trawl net dimensions and codend mesh-size should also be recorded. Power of vessel and presence of

navigational aids such as Global Position Fixing and colour echo sounders are relevant to fishing power of vessels.

Recording species or group of species targeted allows fishing effort to be treated as targeted effort or non-targeted effort in stock assessments.

5.6.3 Index of abundance

Fishery stock assessment requires a time series of an index of abundance that is proportional to stock size. For shark stocks these can be provided from fishery CPUEs and from fishery-independent survey data.

CPUE or catch rate is a valuable index for long-term monitoring of the fishery and is often used as an index of stock abundance, where some relationship is assumed between the index and the stock size. However, CPUE alone can be an unreliable index of stock size. There can be a problem with changes of fishing efficiencies or operational patterns over time; routine surveys of fishing gear should be adopted. Also, CPUE can be misleading in a fishery where fishers targeting aggregations of fish can provide high CPUE while the stock declines rapidly (hyperstability), or, conversely, fishers removing highly vulnerable aggregations in an otherwise diffusely distributed population can cause CPUE to decline much more rapidly than stock abundance (hyperdepletion). CPUE should be separate for each stock unit, fleet and gear type. Where there is complex stock structuring the data need to be spatially disaggregated. Some of the problems of differences in efficiency between vessels and changes in areas fished from year to year can be adjusted by standardisation of CPUEs using generalized linear models; however, standardizations require careful statistical consideration of the residual (error) structures of the data.

Fishery independent survey of fish density with a standard vessel using standard fishing gear can avoid some of the biases inherent in fishery CPUE data. Such surveys can be costly and require careful design, particularly if a stratified sampling design is adopted to improve precision.

5.6.4 Catch composition

Size and/or age data for male and female sharks, separately, provide information on stock structure. Male and female sharks and other chondrichthyans can be readily distinguished by the presence of claspers on males. In fisheries where fishers remove claspers at sea but leave the pelvic fins in tact on females the animals can be sexed, but where the pelvic fins are removed from both males and females then the animals can only be sexed by onboard observers.

Size composition data can be collected by sampling vessel catches. This requires a standardized length measurement for recording lengths of shark. Because sharks are usually headed, gutted and finned, the length measurement has to be a partial length. If the position of junction between caudal fin and body trunk is readily identifiable then the longest reliable partial length on the trunk that can be measured is from the posterior edge of the last gill-slit to the base of the tail. An alternative to the last gill-slit is the anterior margin of the base of the pectoral fin or, where pectoral fins are removed, the anterior margin the pectoral girdle. Other positions on a trunk used for defining partial lengths are the bases of dorsal fins. Where sharks are landed in size categories, it is necessary to sample all categories and to apply raising procedures that lead to accurate estimates of length composition in the catch.

Conversions from partial length of landed carcass to total length or fork length of shark are required to present data in terms of total length or fork length. If it is necessary to adopt more than one standard length measurement, the data should be converted to a single standardized length, ideally total length or fork length.

Age composition of the catch is determined from length-at-age data. This involves determining ages of sharks of known length within each of a number of length-classes covering the full size range of the animals in the catch to provide an age-length key. Age-length keys can be combined with the length-frequency composition of the catch to determine the age-composition of the catch. Ageing chondrichthyans involves counting growth-increment bands in sectioned or whole vertebrae or in other hard parts such as sectioned spines. Ideally age-length keys are determined each year because of continual changes in the age composition of the population.

5.7 Data collection methods

Data should be collected continuously or at intervals sufficiently frequent to give time series data. There are several data collection methods that can be applied.

5.7.1 Fishing registration data

Registers can be used for some variables to obtain complete enumeration through a legal requirement. It is a depository of information on fishing vessels, companies, gear, licences and individual fishers. Required data on vessels include vessel type, vessel size, gear type, country of origin, fish holding capacity, number of fishers, and engine horse power.

Fishing, fish processing and marketing companies are registered for various purposes. Fishing company registers should include data on number of vessels and details of vessels and fishing gear. Fish processing and marketing companies should provide data on type of processing, type of fish and capacity of processing and marketing.

Operators of fishing vessels and fishing gears should be required to hold a valid fishing licence. Unlike vessel registers, fishing licences tend to be issued for access to specific fisheries over a set period of time. Because licences have to be periodically renewed, they provide a useful way of updating information on vessels and fishing gear.

Vessel registers are complex systems requiring well-established administrative procedures supported by effective data communications, data storage and processing components. Being such they have certain types and size of fishing units such as industrial and semi-industrial fleets. Small-scale and subsistence fisheries involving large numbers of fishing units are often not part of a registering system.

5.7.2 Enumerators/Observers

Enumerators, also referred to as observers, can make direct measurements and undertake interviews and surveys using questionnaires either on fishing vessels, at landing sites at processing plants and in markets. Enumerators can collect catch (landings and discards) and fishing effort for selected vessels, biological data, bycatch data, environmental data, value and price of landings and trade data.

At-sea observers can collect catch and effort data, which can be cross checked against a vessel's fishing logbook. Also, they can collect details of the fishing gear, fishing operations, and biological data (sex and length-frequency composition, stage of maturity, fecundity and breeding frequency) and can collect vertebral or dorsal-spine samples for subsequent laboratory ageing.

At landing sites, processing plants and markets, observers can collect landing data (quality, quantity, value and price), carcass form of landings (e.g. headed, gutted and finned), biological data (sex, length-frequency, and vertebral samples) of landing. If sharks are landed whole, stage of maturity and spines can also be collected. Processor and market data on species and quantities purchased can be used for validation of landings reported in logbooks.

5.7.3 Resource-user reporting

Reporting attempts to provide complete enumeration by particular resource users. This involves the preparation of forms by fishing companies, fishers, fish processors, market operators, and sometimes trading companies and custom offices. These data collection methods are best suited to industrial and semi-industrial fisheries.

Fishing companies and fishers can provide basic data on catches and fishing effort, and the submission of such data on logbook forms and/or landings declarations can be made mandatory as a condition of the fishing licence. Logbook forms should contain detailed information on catch by species, individual fishing operations, including fishing grounds (depth and latitude and longitude coordinates or grid reference), type and amount of fishing gear deployed and duration of fishing operations. Landing declarations should be a summary of catch by species for individual fishing trips. Using available company records available in pre-processed computerised format can reduce the costs of collecting the data.

Confidentiality of information (such as fishing grounds) should be part of the agreement for data submission arrangements and statistical summaries made public should not contain information that can be related to an individual vessel or company. There are risks of under-reporting or over-reporting of quantities of catch and revenues from landings and there are risks of deliberate distortion of data, especially for those related to fishing grounds.

Processing factories and markets can be required to report quantities and value of shark received, processed and sold. They could also be required to provide the vessel of origin of the catch and data of sex and length-frequency composition of the sharks handled.

Off-loading catch in processed or whole form requires considerable attention to detail. In some circumstances, off-loading may proceed directly to a processing factory or cold store. Detailed landings can be recorded provided each batch is marked with its source (vessel name, trip identifier). These records also provide information on their output and sales, including destination and price.

Market transaction records can form a feasible way of collecting landings with complete enumeration, particularly in large fleets of small-scale vessels that land in central locations. This requires complete coverage by all invoices, sales slips and sales tallies. These forms should have provision for primary identifiers on the records are name of vessel (or vessels in the case of carrier vessels unloading from distant fleets) selling the catch, the date and trip number, and total weight, price and sale value by species, or species group. These sales records should be prepared in appropriately identified forms with multiple copies for distribution to the market administration, the seller (vessel or company), the buyer and the fisheries authority.

General sales records (market, factory processing and export data) can provide data on volume of sales and prices by product form (carcass, meat, fins, vertebral columns liver, liver-oil and skins). These are valuable for bio-economic analyses but can be of limited benefit for stock assessment if they cannot be related to vessel, fishing grounds, fishing effort or species of shark.

Trade data, which refers to information from customs or other sources of trade, can also provide information on socio-economic variables and, in some cases, information on landings. Information on exports and imports is published by most countries and is important where export and/or import taxes or royalties are payable, or export incentives given. At present, trade data are the only data available for estimating shark landings in many countries. Use of trade data quantities require appropriate conversions to estimate whole weight but the value of the trade data is reduced by the often ambiguity of the form of the product. To be of more use shark products should be specified by species, as frozen or dried, and as:

- whole,
- headed and gutted carcass with skin on and fins on,
- headed and gutted carcass with skin on and fins off,
- headed and gutted carcass with skin off and fins off,
- filleted meat only,
- heads only,
- head cartilage,
- vertebral cartilage,
- powdered cartilage,
- skin only,
- fins only,
- whole livers only, or
- liver-oil.

5.7.4 Fishery-independent survey

Surveys carried out using institutional research vessels or commercial fishing vessels at the level of stock, sub-stock or species can provide indices of stock abundance and distribution. These surveys require fishing with a standard vessel using standard fishing gear at predetermined fishing stations selected according to a fixed-grid, fixed-site or stratified random sampling design. Such surveys should provide, firstly, an estimate of average fish density (per area swept by a trawl net, or as fish encounters with longlines or gillnets) over the entire spatial range where the stock(s) might be found, and, secondly, mapping of the spatial distribution of density over the entire range.

A number of countries undertake regular fishery-independent survey of their trawl fisheries. The available survey data for the more valuable teleost species are regularly analysed but most of data available for sharks and other chondrichthyans have not been systematically analysed. Similarly, fishery-independent survey of tuna and tuna-like fishes have produced valuable bycatch data on sharks that have never been analysed. Hence, opportunities exist to provide indices of abundance for a number of species by analysing available data from these surveys. States and RFMOs should give priority to analysing these data.

5.8 Scientific research

Scientific research is required to measure variables from shark populations and their habitats, and from the fishing gear used to harvest sharks. Such research can be carried out using institutional research vessels or commercial fishing vessels. In addition to fishery-independent survey, scientific research methods can address various objectives, which need to be addressed at the level of species or, in some cases, stock or sub-stock.

One objective is to determine life-history parameters from biological data on sex and length-frequency composition, maturity stage of ovaries and oviducal glands, number and size of ova, and number and size of *in utero* eggs and/or embryos. Samples of vertebrae or dorsal spines should also be collected for subsequent laboratory ageing.

In a gillnet fishery, an objective is to determine how selectivity of gillnets varies with length of shark and mesh-size of gillnet, or, in a hook fishery, an objective is to determine how selectivity of hooks varies with length of shark and hook-size. Determining selectivity parameters requires experiments using gillnets with a range of mesh-sizes or using hooks with a range of hook-size.

In a trawl fishery, an objective is to determine whether bycatch abatement devices can be developed to reduce the catch or kill of shark species.

Laboratory procedures need to be developed for ageing sharks from, depending on species, whole or sectioned vertebrae or from other calcified parts such as sectioned dorsal spines present in some chondrichthyan groups. Also depending on species, the visible clarity of growth-increment bands in these structures require chemical staining and/or special illumination or microradiography to enable interpretation for age estimation.

Tagging programmes can be adopted for estimating growth, mortality and movement rates. Sharks can be successfully tagged with internal tags inserted through the body wall into the coelomic cavity (body cavity), with rototags inserted through the bases anteriorly of dorsal fins and with dart tags inserted between the basal cartilage of the dorsal fins. Dart tags inserted into the muscle issue have low retention rates. Whenever tagging programmes are undertaken, some double tagging should be undertaken to estimate tag retention rates. Also, injecting sharks with oxytetracycline or some other hard tissue stain provides a basis for validating assumptions on the periodicity of growth-increment bands in shark vertebrae and other hard parts adopted for ageing purposes.

Many species of shark have sites where they aggregate for mating or giving birth or they predictably travel along certain migration routes to these areas. It is important to identify these sites and routes as it might be necessary to provide special protection from fishing through closed areas or closed seasons to protect the breeding fish in the population. Scientific research methods can be applied to identify and monitor critical habitats.

In addition, species with well defined nursery areas, where the newborn and young animals are found, may need special protection from the effects of fishing and habitat degradation. The nursery areas are often in shallow inshore areas where they are vulnerable to the effects of habitat change caused by industrial, domestic and agricultural development in coastal and catchment areas. Also, aquaculture, ecotourism, spread of exotic organisms and pollution in the marine environment, and, in some regions of the world, global warming and ozone thinning can impact on the nursery areas. These changes should be carefully monitored.

5.9 Data management

Data must be held in their primary form and there is a need for long-term commitment to supporting data management application. The volume of raw primary data is often very large, and so can only be utilized effectively if it is maintained in a database management system. The functions of a database are to:

- ensure data conform to standard classifications,
- ensure validity of the data,
- ensure data integrity and internal consistency of the data,
- secure and maintain primary data,
- allow easy access to the data to facilitate its synthesis,
- allow different data sets to be integrated, thereby increasing their utility and value.

As computing power increases it is becoming progressively easier and less costly to store and process large primary data sets. It is important database developers be involved in the design of any data collection scheme.

A decentralised database design can be integrated with other local databases to facilitate data management and data validation. Data entered and validated locally should be made accessible to the centralised database.

Monitoring and assessment of transboundary stocks will require regional sharing of data. This will require integrating data collected though different national fishery data collection programmes. Such integration is feasible under the following conditions.

- All contributing national standards and classifications share a common regional or inter-regional set of statistical standards (usually at a high level of aggregation), and that each national database is equipped with necessary logical linkages and cross-references for reporting data at a commonly used level.

- All estimated data (such as totals on catch and fishing effort) are recorded in compatible computer media and use the same exchange formats.

- Automated procedures are in place to speed up the integration process and generate a regional or inter-regional statistical database capable of performing typical data extraction and reporting functions.

- International requirements in terms of variables, data stratification, and standards have been well studied before the national data are compiled from the raw data, so that the data compiled at the national level can be further aggregated at the international level.

5.10 Stock assessment

States and RFMOs should undertake and fully document stock assessment of each of the important species taken in directed fisheries and should document trends in fisheries where sharks are taken as non-targeted species or as discarded bycatch.

The life history traits of sharks differ from those of most teleosts and invertebrates and are more like those of marine and terrestrial mammals, which are of K-selected animals. Hence, in many ways, the dynamics of shark fishery stocks have more in common with marine mammal populations than they do with fisheries based on teleost or invertebrate species. Hence, the application of fishery assessment models must be applied with care.

In the absence of time series data of catches and stock abundance indices, shark populations are assessed using either demographic analysis or yield per recruit analysis which ignore density-dependent regulation. Demographic analysis is the process by which age-specific mortality and natality rates are combined to produce estimates of the net reproductive rate, inter-generation period, and intrinsic (instantaneous) rate of increase. This involves the construction of a cohort or static life table for the population, based on reliable estimates of mortality, natality, and longevity and usually assumes a stable age distribution, equal sex ratios, and a constant recruitment rate. The method of demographic analysis was recently extended to incorporate density-dependent effects by allowing adult mortality to change with population size. Yield per recruit analysis is a simpler form of demographic analysis because it does not include reproductive rates; like demographic analysis it assumes recruitment is constant and independent of stock size.

Stock assessments should incorporate a time-series of total catch estimates in numbers or weight because it represents removal of biomass and individuals from the ecosystem and is the fundamental impact fishing has on fish populations. The assessments should also incorporate a time-series of abundance indices based on CPUE or fishery-independent surveys. Where time-series of catches and stock abundance indices are available, shark populations can be assessed using biomass dynamics models. These models make the assumptions that the rate of population increase responds immediately to changes in population density and that the rate of natural increase at a given density is independent of the age composition of the stock. Whilst these assumptions might be reasonable for

the short-lived more highly productive species, they are most likely invalid for long-lived species of low productivity.

Delay-difference models have advantages over biomass dynamics models in that they can incorporate some biological information. However, neither biomass dynamics nor delay-difference models can incorporate all information on shark reproduction, and both assume 'knife-edge selection' which is not a valid assumption in gillnet or trawl fisheries.

The most appropriate assessment models for sharks are fully age-structured non-equilibrium models that can include time-series of catch and abundance indices, the demographic parameters for growth, reproduction and natural mortality, and fishing gear selectivity parameters. These models can be adapted to incorporate ancillary data such as mean size or mean weight of shark in the catch. They can also be readily adapted to incorporate alternative assumptions on density-dependent mechanisms operating through density-dependent natural mortality, fecundity or growth. These models can also be spatially structured to use spatially disaggregated data and to allow for movement of sharks between different regions of the fishery.

Complex stock structuring of a species requires the stocks to be assessed using a spatially-structured models with spatially-disaggregated data. In some cases multi-stock models are required. Stock assessment of a fishery applying spatially-aggregated models can give highly uncertain results. Allowing for spatial- and stock-structure and combining tag release-recapture data with catch, abundance indices and demographic parameters can markedly reduce uncertainty in assessment.

Assessment of stocks in some fisheries using spatially-structured models might require there to be separate breeding sub-populations but mixing at other life history stages. Such mixing sub-stocks might exhibit philopatry ('home loving') effected through 'natal homing' whereby pregnant female sharks return to their birth place. Under this hypothesis 'stock' can be defined as 'a group of animals that have the same pupping grounds and same movement patterns'. If the females from different stocks mate randomly with males then 'stock' is likely to be memory based rather than genetically based.

For migratory species, spatially-structured models require estimates of movement rates between the various regions of a fishery. One approach involves estimating rates of movement between separate regions, where the rate of movement is the proportion of animals leaving one region to move to another region within a specified time-step. This approach treats the contribution of each tag independently and makes use of information from both the recaptured and non-captured tagged sharks. Data inputs to the model include total fishing effort within discrete time intervals for each type of fishing gear, the gear selectivity function of each fishing gear deployed in the fishery, and region, shark length and date at the time of release and the time of recapture.

Tag release-recapture programmes are often too limited in scale to determine the number of movement parameters required for a fully spatially-structured stock assessment model. One approach is to develop a range of feasible alternative movement hypotheses, which can be developed as simulation models tuned on the basis of varying assumed movement parameter values. These parameter values then can be used as either fixed values or as starting values, which are subsequently re-estimated, in a full spatially-structured stock assessment model.

5.11 Adoption of Sustainable Development Reference System

There are advantages in establishing shark fisheries and shark conservation objectives within the 'sustainable development reference system' (SDRS), as described in the FAO Technical Guidelines for Responsible Fisheries No. 8, Indicators for sustainable development of marine capture fisheries. The SDRS provides a framework with the four 'economic', 'social', 'ecological', and

'governance' dimensions within which to establish 'criteria', set 'objectives' and organize related 'indicators' and their respective 'reference points' (or reference values).

An efficient SDRS selects, organizes and uses indicators to deliver meaningful information about the achievement of sustainable development and policy objectives (including their legal basis) at the desired scale. It is inexpensive and simple to compile and use. It optimizes the use of information, handles different levels of complexity and scales, and facilitates integration and aggregation of indicators. In addition, it provides information that is readily communicable to stakeholders, and can contribute directly to improved decision-making processes. The development of an SDRS involves five steps.

(i) *Specifying the scope of the SDRS.* For sharks, this might be establishing an SDRS for a target shark fishery, for shark bycatch in a fishery targeting non-shark species, or for a shark species requiring 'special management'.

(ii) *Developing a framework for indicator development.* The framework can take a structural approach representing the four dimensions of sustainable development. One favoured framework is the pressure-state-response framework, which considers the pressure imposed by human activities on some aspects of the system, the states of those aspects, and desired societal responses.

(iii) *Specifying criteria, objectives, potential indicators and reference points.* 'Criteria' represent those properties of a system that will be affected by the process of sustainable development. These are determined by the four dimensions of the SDRS and within each dimension, a number of criteria should be defined for the selection of objectives, indicators and reference points. Examples of criteria include harvest, harvest value and fishery net value for the economic dimension; employment, income, fishing tradition and protein consumption for the social dimension; relative abundance, exploitation rate and catch structure for the ecological dimension; and capacity to manage, transparency of process and compliance success for the governance dimension. Criteria enhance communication, transparency, effectiveness and accountability in natural resource management.

'Indicators' assist in the process of assessing the performance of fisheries policies and management at global, regional, sub-regional, national and sub-national levels. They provide a readily understood tool for describing the state of fisheries resources and fisheries activities and for assessing trends relating to SDRS objectives. Indicators play an important role in the communication of scientific results to decision-makers by providing for simple outputs from complex models. Where appropriate within an SDRS dimension, indicators should be developed by firstly identifying objectives, then specifying a model (either conceptual or numerical) of the scientific understanding of the system, and finally determining the variables from the model that indicate performance relative to the objectives and for which information is available or can easily be collected. Indicators must be scientifically valid in the sense that, according to our best scientific understanding, they are indicative of the objective they are intended to reflect and utilize the best scientific information available. Also, indicators should be feasible and cost effective and easily understood. Changes in indicator values over time cannot be meaningfully interpreted in relation to SDRS without considering them in relation to a reference value corresponding to an 'objective', which can be either a target or a constraint (limit) identified for the system.

'Reference values' are conventionally called 'target reference points' and 'limit reference points' (or 'threshold reference points'). The process of developing and stating a set of 'objectives' that is accepted by all stakeholders is itself a major step in the achievement of sustainable development. An SDRS places objectives in perspective and can help make

relationships and trade-offs between objectives explicit. For some criteria, objectives such as maintenance or rebuilding of the fish stock may be well defined international agreements, legislation or public expectation. Others may never have been clearly articulated.

'Objectives' relating to given criteria need to be identified at various levels of the system. Some objectives are implied by existing international agreements or national policies, but others need to be much more specific. Examples of objectives include maintenance of a shark stock or rebuilding of a shark stock. A more specific objective is to maintain the biomass of a stock at a level capable of supporting the optimal sustainable yield that has been specified in relation to two related biomass reference points: $\mathbf{B_{limit}}$, a limit reference point indicating the lowest level of biomass compatible with sustainability of the resource, and $\mathbf{B_{target}}$, a reference point indicating the level of biomass considered appropriate for the fishery and aimed at for management.

(iv) *Choosing a set of indicators and reference points.* The framework, the criteria and the objectives relating to each criterion should jointly give an agreed representation of what sustainable development means for a fishery, and should usually make indicator and reference point development self evident. For example if the objective is to maintain fishing mortality at a set level, then the indicator and its reference point are immediately defined. Where the objectives are less quantitative, the indicators and reference points are more difficult to define. In general, indicators should be based on policy priorities, practicality, data availability, cost-effectiveness, understanding, accuracy and precision, robustness to uncertainty, scientific validity, acceptability to stakeholders, ability to communicate information, timeliness, legal foundation, and adequate documentation.

There are five steps in choosing indicators and reference points: (i) determine criteria and specific or implied objectives, (ii) develop a conceptual model of how the system works around which to organize them, (iii) determine what indicators and potential reference points are needed for assessing progress towards the objectives, (iv) consider feasibility, data availability, cost and other factors determining the practicality of implementing the indicators, and (v) document the methods used to calculate or specify the indicators.

(v) *Specifying the method of aggregation and visualization.* Indicators and their interpretation need to be presented in a form easily understood by the user. Indicators can be presented as a simple value, but to compare indicators within and between different systems rescaling will be necessary. This requires converting the indicator into a ratio to create a 'relative reference point'. For example, if a reference value of mature biomass (e.g. initial mature biomass) is prescribed then the rescaled indicator would be a ratio (or proportion) of this value and would lie in the range 0–1. There are advantages in relating the scale of the indicator to value judgements (e.g. 'good', fair', 'poor') on the extent societal objectives are met.

5.12 Risk management and risk assessment

The 'precautionary approach' (see Section 1.4) and the Sustainable Development Reference System (see section 5.11) together provide a 'risk management' decision-making framework for conservation of shark species and management of shark fisheries. Making decisions involves risk of an undesirable outcome resulting from uncertainty. Accounting for uncertainty in conservation of species and management of fisheries requires 'risk assessment'.

'Risk assessment' for a shark stock involves quantifying uncertainty in the results from an assessment model incorporating the population dynamics of the stock given the adopted model with all its implicit and explicit assumptions and given the available data. To assess risk, the model has to include stochastic components, where one or more parameters of the model are expressed as

probability distributions and/or the data, such as a time series of abundance indices, are fitted to the model as probability distributions rather than as simply mean values.

When applied to a harvested shark population, 'risk assessment' is concerned, for example, with calculating the probability that the population size will fall below a specified level ('biological reference point'). Here population size might be total biomass, mature biomass, total number of animals, number of recruits, number of births or some other quantity, usually expressed as a proportion of the initial (pre-fishing) population size. Under the SDRS, these are 'indicators' relating to stock abundance as a 'criterion', the 'biological reference point' would be a 'limit reference point' and/or 'target reference point', and the management 'objective' would be to maintain the population size above the specified 'reference point'. For 'risk management', however, each 'reference point' needs to be expressed with a 'level of risk' and a 'time period for the risk'. Together these provide an appropriate framework for 'risk analysis' for stock assessment and, through forward projections, for evaluation of alternative harvest strategies. It also provides a framework for developing decision rules agreed to through a consultation process. Subsequently, in the event that the agreed assessment model with the agreed data predicts the 'indicator' falls below the 'reference point' (the adverse event) at the nominated risk probability within a specified time period, management actions can then be promptly implemented the need for extensive consultation. An example of how this might work would be to implement agreed and prescribed changes to the adopted (current) harvest strategy for a shark fishery if say the assessment model predicted that within 7 years (adopted 'time period') the mature biomass of the stock had a 20% probability risk (adopted risk level) of falling to below 40% of initial mature biomass (adopted 'limit reference point').

6. FISHERIES MANAGEMENT AND SPECIES CONSERVATION

The capacity to manage shark fisheries and conserve species depends on available human and financial resources as well as on the existence of competent institutions. Fisheries management requires an investment of time and resources to collect the needed information, to develop and agree on a management regime, to enforce regulations, and to monitor the fishery. An economically sound fishery should make acceptable returns on investments after the costs of management are accounted for. In subsistence fisheries, management institutions and Shark Plans need to rely more on traditional power structures and culture than on formal management plans.

The management of fisheries to achieve specific goals and objectives requires the development and application of a set of rules that govern the behaviour of fishers permitted to enter a fishery and the gear they use. Rules also govern the behaviour of those not permitted in the fishery, and those without rights of access to certain parts of the fishery. Fisheries practices should be adopted that avoid conflict among fisheries resources users and between these fisheries users and non-fisheries users of resources.

6.1 Resource constraints

Shark and other chondrichthyan species generally have relatively low productivity and therefore require careful management and monitoring if they are to be utilized sustainably. Hence, in multispecies fisheries where the main target species are bony fishes, sharks landed as non-target species or caught as discarded bycatch might require 'special management' to prevent severe depletion. Some species of shark are apex predators and naturally have comparatively small population sizes. Whereas some species have very wide geographic distributions, others have very restricted ranges falling within the full range of a fishery or the range of other anthropogenic influences (see Appendix 2). Some species have critical habitats such a nursery, parturition and mating areas and migration lanes, which might need special protection.

6.2 Options to regulate fishing

6.2.1 Control of catch or fishing effort

Fishery managers should ensure that no vessel is allowed to capture sharks or take sharks as bycatch unless authorised in a manner consistent with international law for the high seas or in conformity with national legislation within areas of national jurisdiction.

Fishery managers should ensure that where excess fishing capacity for the capture of sharks exists, mechanisms should be established to reduce capacity to levels commensurate with the sustainable use of shark fishery resources.

Fishery managers should ensure that critical habitats are protected and, where affected by fishing or other human activities, are restored.

Fishery mangers should take appropriate measures to give special attention to protect new-born and young juveniles and breeding adults, particularly for species, which have nursery, pupping and mating grounds. Where appropriate, such measures may include technical measures related to size of shark, use of environmentally safe fishing gear, selectivity of fishing gear, closed seasons and closed areas.

6.2.2 Control of fishing gear

Fishery managers should ensure that existing fishing methods and practices, which are not consistent with responsible shark fishing, are phased out and replaced with more acceptable alternatives. Regulation of fishing gear can be used for control of fishing mortality.

Fishing gear and biological characteristics affect a species' catchability. Pelagic and semipelagic species that actively swim in the water column are more likely to encounter a gillnet or baited hook and therefore have a higher catchability than sluggish species such as the angel shark, saw shark, certain dogfishes, and batoids that can rest on the seabed. These bottom-dwelling species, on the other hand, are more vulnerable than the more powerful swimming species to demersal trawling.

The fishing gear and biological characteristics can contribute to various kinds of mortality referred to as 'unaccounted fishing mortality' or as 'collateral mortality'. When captured by gillnet or hook, fast swimming species, dependent on ram-jet ventilation of their gills for respiration tend to die more quickly than bottom-dwelling species when caught. Bottom-dwelling species with well developed spiracles to aid gill ventilation are better able to ventilate their gills after capture by gillnets and can struggle vigorously to either escape or become more tightly enmeshed in the gear. Dead sharks not tightly enmeshed can drop out of gillnets and contribute to 'unaccounted fishing mortality' through 'drop-out mortality'. Sharks eaten by other fish or mammals after capture in the gear contributes to 'unaccounted fishing mortality' through 'predation mortality'. Dead sharks either partly or totally decomposed or eaten by invertebrates and vertebrates when fishing gear is left in the water for extended periods also contributes to 'unaccounted fishing mortality'. Also, lost gillnets contribute to 'unaccounted fishing mortality' through 'ghost fishing mortality' until they are rolled into a ball by tidal flow.

Fishing gear selectivity gives rise to a range of complexities that relate to the dynamics of harvested shark species. Selectivity by trawl nets for size of shark is not well understood, and hook-size selectivity for size of shark has been shown to be weak. In gillnets, however, sharks of different sizes are not equally vulnerable to capture. Small sharks swim through gillnets but become progressively more vulnerable to capture as they grow. After reaching the length of maximum vulnerability they then become progressively less vulnerable with further growth as their heads cannot so readily penetrate the meshes of the nets. These size selectivity effects are stronger for fusiform-shaped sharks

than for more dorsoventrally-flattened species or for species with protruding structures such the heads of hammerhead sharks, the rostral teeth of saw sharks and sawfishes, and the dorsal spines of dogfishes, horn sharks and chimaeras. For some species careful regulation of mesh-size can be used to ensure the sharks are large enough to avoid growth overfishing and small enough to facilitate escapement of large breeding animals.

6.3 Bycatch reduction

Fishery managers should investigate options for fitting 'bycatch reduction devices' in trawl nets to allow escapement of sharks, skates, rays and chimaeras, and regulating construction of the fishing gear and fishing time for gillnets and hooks.

The type of fishing gear used and the species of shark taken as bycatch determines which techniques and equipment are appropriate for minimising bycatch. For trawl nets, there is evidence that catches of sharks have been reduced when fitted with 'turtle exclusion devices', suggesting there could be advantages investigating alternative devices designed specifically to exclude sharks. Also, there is scope to reduce bycatch of sharks in gillnets by regulating mesh-size and possibly the breaking strain of the webbing filaments. Most species of shark remain alive on hooks for extended periods and can be released alive, but there might be scope to improve survival of sharks by prohibiting the use of wire traces used to attach hooks to the snoods on a longline and by regulating for reduced breaking strains of the snoods. Wire traces reduce the probability of hooks being bitten off the snoods.

6.4 Encouragement of full utilization

Fishery managers should take appropriate measures to minimize waste of shark, discard of dead sharks, shark catch by lost or abandoned gear, shark catch of non-target species, and negative impacts on associated or dependent shark species, in particular, endangered shark species. Where appropriate, such measures may include technical measures related to size of shark, quantity of fishing gear, mesh-size of fishing gear, discard of sharks, closed seasons and closed areas.

6.5 Species conservation

Naturally rare species and species with poor conservation status may require special protection or management through such measures as a prohibition on catch, injury and interference. Where naturally rare species and species with poor conservation status are inevitably killed, injured or interfered with accidentally, consideration should be given to establishing sanctuaries through fishing exclusion zones.

6.6 Biodiversity and ecological considerations

It is not possible to operate a fishery without affecting the original equilibrium of stocks. Fisheries management should promote the maintenance of the quality, diversity and availability of shark fishery resources in sufficient quantities for present and future generations in the context of food security, poverty alleviation and sustainable development. Management measures should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated with or dependent on the target species.

Fisheries management is required by the 1982 UN Convention on Law of the Sea and by the Code of Conduct for Responsible Fisheries to restore depleted populations to levels above those at which maximum productivity occurs (e.g. to biomass levels higher than the level corresponding to the Maximum Sustainable Yield). This reflects current thinking that providing a margin for safety that takes into account normal variability and uncertainty requires using Maximum Sustainable Yield for fisheries management, rather than as a target.

7. IMPLEMENTATION OF THE IPOA-SHARKS

7.1 Development of Shark Plans

Procedures for States and RFMOs to implement national, sub-regional or regional Shark Plans consistent with the IPOA-Sharks is prescribed in paragraphs 17–28 of the IPOA-Sharks (see Appendix 1(a)). These paragraphs are summarised in the following, and where appropriate expanded to provide additional information.

The IPOA-Sharks applies to States in the waters of which sharks are caught by their own or foreign vessels and to States the vessels of which catch sharks on the high seas. States should adopt a national plan of action for conservation and management of shark stocks (Shark Plan) if their vessels conduct directed fisheries for sharks or if their vessels regularly catch sharks in non-directed fisheries. Similarly States which have sub-regional arrangements or are members of RFMOs should, where appropriate, cooperate with a view to coordinating the Shark Plans of their members for the purpose of developing one or more joint Shark Plans. This is particularly important where transboundary, straddling, highly migratory and high seas stocks of sharks are exploited by two or more States. When developing a Shark Plan, experience of States with sub-regional arrangements and RFMOs should be taken into account, as appropriate. States, which determine that a Shark Plan is not necessary, should review that decision on a regular basis taking into account changes in their fisheries, but as a minimum, data on catches, landings and trade should be collected.

Where appropriate sub-regional arrangements and RFMOs should also develop Shark Plans. Organizations such as the Inter-American Tropical Tuna Commission, the International Council for the Exploration of the Sea, the International Commission for the Conservation of Atlantic Tunas, the Northwest Atlantic Fisheries Organization, the Sub-regional Fisheries Commission of West African States, the Latin American Organization for Fishery Development, the Indian Ocean Tuna Commission, the Commission for the Conservation of Southern Bluefin Tuna and the Oceanic Fisheries Programme of the Pacific Community have initiated efforts encouraging member countries to collect information about sharks. In some cases they have developed regional databases for the purpose of stock assessment.

States and RFMOs should carry out a regular assessment of the status of shark stocks subject to fishing so as to determine if there is a need for development of a Shark Plan. The assessment should be reported as a part of each relevant State's Shark Plan in the suggested format below. The assessment would necessitate consistent collection of data outlined in the earlier section of these guidelines. International collaboration on data collection and data sharing systems for stock assessments is particularly important in relation to transboundary, straddling, highly migratory and high seas shark stocks.

The aim of the Shark Plan is to:

- Ensure that shark catches from directed and non-directed fisheries are sustainable;
- Assess threats to shark populations, determine and protect critical habitats and implement harvesting strategies consistent with the principles of biological sustainability and rational long-term economic use;
- Identify and provide special attention, in particular to vulnerable or threatened shark stocks;
- Improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders in research, management and educational initiatives within and between States;
- Minimize unutilized incidental catches of sharks;

- Contribute to the protection of biodiversity and ecosystem structure and function;
- Minimize waste and discards from shark catches in accordance with article 7.2.2.(g) of the Code of Conduct for Responsible Fisheries (for example, requiring the retention of sharks from which fins are removed);
- Encourage full use of dead sharks;
- Facilitate improved species-specific catch and landings data and monitoring of shark catches;
- Facilitate the identification and reporting of species-specific biological and trade data.

7.2 FAO assistance

The role of FAO is prescribed in paragraphs 29–31 of the IPOA-Sharks. In addition to preparing these guidelines, FAO, as part of its Regular Programme of activities, support States in the implementation of the IPOA-Sharks, including the preparation of Shark Plans and provision of in-country technical assistance. FAO will provide a list of experts and a mechanism of technical assistance to countries in connection with development of Shark Plans. FAO will report biennially through COFI on progress of the implementation of the IPOA-Sharks.

States and RFMOs should strive to collaborate through FAO and through international arrangements in research, training and the production of information and educational material.

7.3 Suggested format for national, sub-regional and regional Shark Plans

States and RFMOs should strive to have a Shark Plan by the COFI Session to be held during February 2001. Those entities that implement the Shark Plan should regularly, at least every four years, assess its implementation for the purpose of identifying cost-effective strategies for increasing its effectiveness. National and regional differences in fisheries are such that the goal of reporting by all nations requires flexibility. Nevertheless there are important steps that should be followed in developing a Shark Plan or preparing a Shark Assessment, and there are certain minimum requirements for the type of information to be reported. The type of information required for Shark Plans is given in the earlier sections of the guidelines and suggested subject headings are given as follows.

1 Introduction
  1.1 Issues

2 Legal, institutional and management framework requirements

3 Human resources and capacity building requirements

4 National and regional fishery management data and research
  4.1 Brief shark fishery descriptions
  4.2 Associated species as discarded bycatch
  4.3 Species identification, distribution and stock structure of harvested species
  4.4 Associated species as discarded bycatch
  4.5 Fishery monitoring and data collection methods
  4.6 Scientific research
  4.7 Data management
  4.8 Stock assessment information
  4.9 Identification of species requiring 'special management'

5 Fishery management and species conservation
  5.1 Resource constraints
  5.2 SDRS criteria, objectives, indicators and reference points

5.3 Options of regulating fishing
5.4 Bycatch reduction
5.5 Encouragement of full utilization
5.6 Biodiversity and ecological considerations

7.4 Suggested format for Shark Assessment Report

States and RFMOs should report on the progress of the assessment, development and implementation of their Shark Plans as part of their biennial reporting to FAO on the Code of Conduct for Responsible Fisheries. The type of information required for the management plan is given in the earlier sections of the guidelines and suggested subject headings and format are given as follows for fisheries taking shark. A good guide to the level of detail is given in the 'Case studies of the management of elasmobranch fisheries' published in the *FAO Fisheries Technical Paper* 378. Shark Assessment Reports for species requiring 'special management' do not require as extensive reporting as shark fisheries and many of the suggested headings can be omitted.

1 Introduction
1.1 Issues

2 The resource
2.1 Species composition of fishery
2.2 Distribution of fishery
2.3 Associated species either as non-targeted catch or discarded bycatch
2.4 Development and current status of means of prosecuting the fishery
2.5 The harvest process
2.6 Evolution of catch
2.7 Fleet characteristics, evolution of the fleet and fishing effort
2.8 Markets

3 Management objectives
3.1 The fisheries within the context of national fisheries policies
3.2 Objectives for the management of the shark fisheries
3.3 The objective setting process

4 Management policies and the policy setting process
4.1 Identification and evaluation of policies
4.2 Policies adopted
4.3 Resource access
4.4 Gear restrictions
4.5 Vessel regulations
4.6 Biological regulations
4.7 Catch/quota allocation
4.8 Species 'special management'

5 The management planning process
5.1 Provision of resource management advice
5.2 Fishery statistics
5.3 Methods used for collection of catch and effort data
5.4 Evaluation of catch and effort data
5.5 Data processing, storage and accessibility
5.6 Stock assessment
5.7 Measures of stock abundance
5.8 Biological advice review process
5.9 Biological management reference points
5.10 Sustainability of the resource

6 Fishery management regulations
- 6.1 Regulations
- 6.2 Regulations and the communication process

7 Law and enforcement
- 7.1 Legal status
- 7.2 Enforcement problems
- 7.3 Surveillance
- 7.4 The legal process

8 Management success
- 8.1 Profitability of the fishery
- 8.2 Issues of equity and efficiency
- 8.3 Management costs

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APPENDIX I

INTERNATIONAL PLANS OF ACTION - SHARKS

Introduction

1. For centuries artisanal fishermen have conducted fishing for sharks sustainably in coastal waters, and some still do. However, during *recent* decades modern technology in combination with access to distant markets have an increase in effort and yield of shark catches, as well as an expansion of the areas fished.

2. There is concern over the increase of shark catches and the consequences this has for the populations of some shark species in several areas of the world's oceans. This is because sharks often have a close stock-recruitment relationship, long recovery times in response to over-fishing (low biological productivity because of late sexual maturity; few off-spring, albeit with low natural mortality) and complex spatial structures (size/sex segregation and seasonal migration).

3. The current state of knowledge of sharks and the practices employed in shark fisheries cause problems in the conservation and management of sharks due to lack of available catch, effort, landings and trade data, as well as limited information on the biological parameters of many species and their identification. In order to improve knowledge on the state of shark stocks and facilitate the collection of the necessary information, adequate funds are required for research and management.

4. The prevailing view is that it is necessary to better manage directed shark catches and certain multispecies fisheries in which sharks constitute a significant bycatch. In some cases the need for management may be urgent.

5. A few countries have specific management plans for their shark catches and their plans include control of access, technical measures including strategies for reduction of shark bycatches and support for full use of sharks. However, given the wide-ranging distribution of sharks, including on the high seas, and the long migration of many species, it is increasingly important to have international cooperation and coordination of shark management plans. At the present time there are few international management mechanisms effectively addressing the capture of sharks.

6. The Inter-American Tropical Tuna Commission, the International Council for the Exploration of the Sea, the International Commission for the Conservation of Atlantic Tunas, the Northwest Atlantic Fisheries Organization, the Sub-regional Fisheries Commission of West African States, the Latin American Organization for Fishery Development, the Indian Ocean Tuna Commission, the Commission for the Conservation of Southern Bluefin Tuna and the Oceanic Fisheries Programme of the Pacific Community have initiated efforts encouraging member countries to collect information about sharks, and in some cases developed regional databases for the purpose of stock assessment.

7. Noting the increased concern about the expanding catches of sharks and their potential negative impacts on shark populations, a proposal was made at the Twenty-second Session of the FAO Committee on Fisheries (COFI) in March 1997 that FAO organize an expert consultation, using extra-budgetary funds, to develop Guidelines leading to a Plan of Action to be submitted at the next Session of the Committee aimed at improved conservation and management of sharks.

8. This International Plan of Action for Conservation and Management of Sharks (IPOA-Sharks) has been developed through the meeting of the Technical Working Group on the Conservation and Management of Sharks in Tokyo from 23 to 27 April 19984 and the Consultation on Management of Fishing Capacity, Shark Fisheries and Incidental Catch of Seabirds in Longline Fisheries held in Rome from 26 to 30 October 1998 and its preparatory meeting held in Rome from 22 to 24 July 1998.

9. The IPOA-Sharks consists of the nature and scope, principles, objective and procedures for implementation (including attachments) specified in this document.

Nature and Scope

10. The IPOA-Sharks is voluntary. It has been elaborated within the framework of the Code of Conduct for Responsible Fisheries as envisaged by Article 2 (d). The provisions of Article 3 of the Code of Conduct apply to the interpretation and application of this document and its relationship with other international instruments. All concerned States6 are encouraged to implement it.

11. For the purposes of this document, the term "shark" is taken to include all species of sharks, skates, rays and chimaeras (Class Chondrichtyes), and the term "shark catch" is taken to include directed, bycatch, commercial, recreational and other forms of taking sharks.

12. The IPOA-Sharks encompasses both target and non-target catches.

Guiding Principles

13. Participation. States that contribute to fishing mortality on a species or stock should participate in its management.

14. Sustaining stocks. Management and conservation strategies should aim to keep total fishing mortality for each stock within sustainable levels by applying the precautionary approach.

15. Nutritional and socio-economic considerations. Management and conservation objectives and strategies should recognize that in some low-income food-deficit regions and/or countries, shark catches are a traditional and important source of food, employment and/or income. Such catches should be managed on a sustainable basis to provide a continued source of food, employment and income to local communities.

Objective

16. The objective of the IPOA-Sharks is to ensure the conservation and management of sharks and their long-term sustainable use.

Implementation

17. The IPOA-Sharks applies to States in the waters of which sharks are caught by their own or foreign vessels and to States the vessels of which catch sharks on the high seas.

18. States should adopt a national plan of action for conservation and management of shark stocks (Shark Plan) if their vessels conduct directed fisheries for sharks or if their vessels regularly catch sharks in non-directed fisheries. Suggested contents of the Shark Plan are found in Appendix A. When developing a Shark Plan, experience of sub-regional and regional fisheries management organizations should be taken into account, as appropriate.

19. Each State is responsible for developing, implementing and monitoring its Shark Plan.

20. States should strive to have a Shark Plan by the COFI Session in 2001.

21. States should carry out a regular assessment of the status of shark stocks subject to fishing so as to determine if there is a need for development of a Shark Plan. This assessment should be guided by article 6.13 of the Code of Conduct for Responsible Fisheries. The assessment should be reported as a part of each relevant State's Shark Plan. Suggested contents of a shark assessment report are found in

Appendix B. The assessment would necessitate consistent collection of data, including inter alia commercial data and data leading to improved species identification and, ultimately, the establishment of abundance indices. Data collected by States should, where appropriate, be made available to, and discussed within the framework of, relevant sub-regional and regional fisheries organizations and FAO. International collaboration on data collection and data sharing systems for stock assessments is particularly important in relation to transboundary, straddling, highly migratory and high seas shark stocks.

22. The Shark Plan should aim to:

- Ensure that shark catches from directed and non-directed fisheries are sustainable;
- Assess threats to shark populations, determine and protect critical habitats and implement harvesting strategies consistent with the principles of biological sustainability and rational long-term economic use;
- Identify and provide special attention, in particular to vulnerable or threatened shark stocks;
- Improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders in research, management and educational initiatives within and between States;
- Minimize unutilized incidental catches of sharks;
- Contribute to the protection of biodiversity and ecosystem structure and function;
- Minimize waste and discards from shark catches in accordance with article 7.2.2.(g) of the Code of Conduct for Responsible Fisheries (for example, requiring the retention of sharks from which fins are removed);
- Encourage full use of dead sharks;
- Facilitate improved species-specific catch and landings data and monitoring of shark catches;
- Facilitate the identification and reporting of species-specific biological and trade data.

23. States which implement the Shark Plan should regularly, at least every four years, assess its implementation for the purpose of identifying cost-effective strategies for increasing its effectiveness.

24. States which determine that a Shark Plan is not necessary should review that decision on a regular basis taking into account changes in their fisheries, but as a minimum, data on catches, landings and trade should be collected.

25. States, within the framework of their respective competencies and consistent with international law, should strive to cooperate through regional and sub-regional fisheries organizations or arrangements, and other forms of cooperation, with a view to ensuring the sustainability of shark stocks, including, where appropriate, the development of sub-regional or regional Shark Plans.

26. Where transboundary, straddling, highly migratory and high seas stocks of sharks are exploited by two or more States, the States concerned should strive to ensure effective conservation and management of the stocks.

27. States should strive to collaborate through FAO and through international arrangements in research, training and the production of information and educational material.

28. States should report on the progress of the assessment, development and implementation of their Shark Plans as part of their biennial reporting to FAO on the Code of Conduct for Responsible Fisheries.

Role of FAO

29. FAO will as, and to the extent directed by its Conference, and as part of its Regular Programme activities, support States in the implementation of the IPOA-Sharks, including the preparation of Shark Plans.

30. FAO will, as and to the extent directed by its Conference, support development and implementation of Shark Plans through specific, in-country technical assistance projects with Regular Programme funds and by use of extra-budgetary funds made available to the Organization for this purpose. FAO will provide a list of experts and a mechanism of technical assistance to countries in connection with development of Shark Plans.

31. FAO will, through COFI, report biennially on the state of progress in the implementation of the IPOA-Sharks.

APPENDIX II

SUGGESTED CONTENTS OF A SHARK PLAN

Background

When managing fisheries for sharks, it is important to consider that the state of knowledge of sharks and the practices employed in shark catches may cause problems in the conservation and management of sharks, in particular:

- Taxonomic problems
- Inadequate available data on catches, effort and landings for sharks
- Difficulties in identifying species after landing
- Insufficient biological and environmental data
- Lack of funds for research and management of sharks
- Little coordination on the collection of information on transboundary, straddling, highly migratory and high seas stocks of sharks
- Difficulty in achieving shark management goals in multispecies fisheries in which sharks are caught.

Content of a Shark Plan

The Technical Guidelines on the Conservation and Management of Sharks, under development by FAO, provide technical guidance, both on the development and the implementation of the Shark Plan. Guidance will be provided on:

- Monitoring.
- Data collection and analysis.
- Research.
- Building of human capacity.
- Implementation of management measures.

The Shark Plan should contain:

A. Description of the prevailing state of:

- Shark stocks, populations
- Associated fisheries and,
- Management framework and its enforcement.

B. The objective of the Shark Plan

C. Strategies for achieving objectives. The following are illustrative examples of what could be included:

- Ascertain control over access of fishing vessels to shark stocks
- Decrease fishing effort in any shark where catch is unsustainable
- Improve the utilization of sharks caught
- Improve data collection and monitoring of shark fisheries

- Train all concerned in identification of shark species
- Facilitate and encourage research on little known shark species
- Obtain utilization and trade data on shark species.

APPENDIX III

SUGGESTED CONTENTS OF A SHARK ASSESSMENT REPORT

A shark assessment report should *inter alia* contain the following information:

- Past and present trends for:
  - Fishing effort: directed and non-directed fisheries; all types of fisheries; and
  - Yield: physical and economic.
- Status of stocks.
- Existing management measures:
  - Control of access to fishing grounds;
  - Technical measures (including bycatch reduction measures, the existence of sanctuaries and closed); and
  - Monitoring, control and surveillance.
- Effectiveness of management measures.
- Possible modifications of management measures.

APPENDIX IV

CLASSIFICATION OF SHARK FISHERIES

Coastal hook and gillnet fisheries: In any region, the methods of fishing depend on topography of the fishing grounds and the available species mix of both sharks and teleosts. In regions of broad continental shelf much of the artisan catch is taken by bottom-set gillnets, mostly constructed of monofilament webbing with some constructed of multifilament webbing, and bottom-set longlines. These take a wide variety of shark species and teleost species. In regions of narrow continental shelves, where deep waters off the continental shelf are readily accessible, or, in regions of broader continental shelves, the artisanal fleet use surface-set longlines and driftnets to target pelagic sharks.

Demersal trawl bycatch fisheries: Demersal trawl fisheries are impacting stocks of dogfishes (Squalidae), angel sharks (*Squatina* spp.), batoids and chimaeras. As in the high seas fisheries, much of the trawl bycatch of sharks and batoids is discarded dead and often not reported. Fishery-independent surveys in several parts of the world show these groups have exhibited marked declines in abundance.

Deepwater bycatch fisheries: Like many of the teleost species studied from the deeper and colder waters of the continental slopes, the deepwater dogfishes (notably genera such as *Centrophorus*, *Centroscymnus*, *Etmopterus*, *Dalatias*, and *Deania*) are likely to have particularly low productivity. The continental slopes are usually steep and the total area of associated seabed is small compared with the areas on top of the continental shelves and on the abyssal plains of the oceans. As some species of dogfish are confined to limited depth-ranges on these slopes, the total areas occupied by some of these species is small. Expansion of demersal trawl fisheries into progressively deeper water to target high valued teleosts on the continental slopes in some regions of the world is placing several species at high risk of severe depletion. Already demersal trawling of the abyssal plain at depths exceeding 1000 m. Some of the catch is targeted or is bycatch taken by gillnets and hooks.

Pelagic shark bycatch fisheries. Longline, purse seine and driftnet fisheries targeting tunas and tuna-like species on the high seas and in the Exclusive Economic Zones through bilateral access agreements take large bycatches. Although most nations have no requirement to record shark catch or to provide a species breakdown of the catch from these fisheries, research cruises and observer programmes on-board longline vessels indicate blue shark (*Prionace glauca*) is the main species caught. Other species caught widely in lower quantities include *Isurus oxyrinchus*, *Alopias supercilious*, *Carcharhinus longimanus*, and *Lamna nasus*.

Freshwater fisheries: Some of the most threatened species of sharks are those occurring in freshwater habitats. There are several reasons why these species are more vulnerable than those inhabiting marine waters. The amount of freshwater in rivers and lakes is small compared with the amount of seawater on Earth. The tropical rivers and lakes where freshwater species occur are mostly in developing countries with large and expanding human populations. These areas are much more accessible to exploitation than marine waters. Freshwater habitats are also less stable than marine habitats in terms of water temperature, dissolved oxygen, clarity and water flow, and these factors are gradually being changed through deforestation. Contamination of the water with toxicants from mining and agriculture, physical modifications to the waterways through dam construction and irrigation, and inevitable changes to the flora and fauna in freshwater habitats are likely to alter them beyond the tolerance of some shark species. At least three species of 'river shark' are now extremely rare. The Ganges shark (*Glyphis gangeticus*) is known only from the Ganges-Hooghly River system of the Indian subcontinent, although it is possible that more than one species of the genus *Glyphis* occurs in the region of Borneo, northern Australia and New Guinea.

These guidelines have been produced to support implementation of the International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks). They are addressed to decision-makers and policy-makers associated with conserving shark and other chondrichthyan species and with managing the harvest of these resources, but they should also be of interest to fishing industries and other parties.

The IPOA-Sharks is consistent with the FAO Code of Conduct for Responsible Fisheries, agreements from the 1995 United Nations Conference on Straddling Fish Stocks and Migratory Fish Stocks, and any applicable rules of international law. It encompasses all shark and other chondrichthyan fisheries, both target and non-target fisheries, whether they be industrial, artisanal or traditional fisheries or fishing programmes designed to reduce the risk of shark attack on humans.

The guidelines are intended to provide general advice and a framework for development and implementation of Shark Plans and Shark Assessment Reports prepared at national, subregional and regional levels. They are also intended to provide general advice and a framework for joint Shark Plans for shared transboundary species of shark. They cover the four elements ("species conservation", "biodiversity maintenance", "habitat protection" and "management for sustainable use") of the IPOA-Sharks and the four dimensions (ecological, economic, social and governance) of the FAO Sustainable Development Reference System.

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